Environment and Ecology 43 (3) : 583—590, July—September 2025
Article DOI: https://doi.org/10.60151/envec/HEFK6873
ISSN: 0970-0420 (Print), ISSN: 3049-3625 (Online)

Effect of Benzyladenine and Boron on Development of Dragon Fruit (*Hylocereus costaricensis* (Web.) Britton and Rose)

Tannu Kumari, Sutanu Maji, Manya Kumari, Kanak Lata, Tanay Anand, Yazhini

Received 24 April 2025, Accepted 13 June 2025, Published on 2 July 2025

ABSTRACT

Dragon fruit (*Hylocereus* sp.) is a perennial vine belonging to Cactaceae family with fruits having unique appearance and night blooming flowers having sweet fragrance. *Hylocereus costaricensis* is a purple red fleshed dragon fruit species which is widely known for its vibrant flesh color, refreshing taste and high nutritive value even though the fruit size is comparatively smaller than the other dragon fruit species. There are several effects of plant growth regulators and micronutrients on physical and chemical properties of fruit but the research regarding their effect on dragon fruit growth and development is limited. The present investigation was planned to know the effect of benzyladeninee and boron on physical and chemical properties of dragon fruit (*Hylocereus costaricensis* (Web.) Britton and Rose) under Lucknow sub-tropical climatic condition. There were 9 treatments (T_1 -Control, T_2 -BA@150 ppm, T_3 -BA @200 ppm, T_4 -Boron @100 ppm, T_5 -Boron @150 ppm, T_6 -BA @150 ppm + Boron @100 ppm, T_7 -BA @ 150 ppm+ Boron @ 150 ppm, T_8 -BA @ 200 ppm +Boron @ 100 ppm, T_9 -BA @ 200 ppm + Boron @ 150 ppm) with three replications laid out following Randomized Block Design. There were 4 plants per pole and poles were planted at 4m × 2m spacing. Findings of the present investigation revealed that both BA and Boron had positive effect on physical and chemical properties of dragon fruit. Boron @ 150 ppm improved the physical quality parameters of dragon fruit followed by combined application of benzyladenine @ 200 ppm + boron @ 150 ppm which improved the chemical qualities of red fleshed dragon fruit.

Keywords Dragon fruit, Plant bio- regulators, Benzyladenine, Boron.

INTRODUCTION

Dragon fruit (*Hylocereus* spp.) is considered as the newly recognized fruit crop introduced to India. It is a perennial climbing cactus belonging to family Cactaceae and sub- family Cactoideae having chromosome number (2n=22) with succulent stem and aerial roots having various names in different parts of the world

Tannu Kumari[1], Sutanu Maji[2]*, Manya Kumari[3], Kanak Lata[4], Tanay Anand[5], Yazhini[6]

[2]Associate Professor
[1,2,3,4,5,6]Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow 226025, India

Email: majisutanu@gmail.com
*Corresponding author

such as Pitaya, Queen of Night, Strawberry Pear, Jesus in the Cradle, Honourable Queen, Belle of Night and Night Blooming Cereus. It blooms at night with high fragrance that typically last for one night (Martin *et al.* 1987, Maji 2019). The fruit is round and oblong in shape, with red or yellow color skin with green scales and white or red flesh with numerous black seeds embedded in it. There are four species of dragon fruit popular worldwide such as, *Hylocereus undatus* (Haworth) Britton and Rose having red-colored rind with white flesh; *Hylocereus polyrhizus* (F. A. C. Weber) Britton and Rose has red-colored rind with red flesh; *Hylocereus costaricensis* (Web.) Britton and Rose having red-colored rind with purple red flesh and *Selenicereus megalanthus* having yellow-colored rind with white flesh (Lalit *et al.* 2018). Dragon fruit has captured the imagination of consumers worldwide with its unique appearance, vibrant flesh color, and refreshing taste (Nguyen *et al.* 2019). This commercially important fruit crop, native to Central and South America, has gained significant popularity in tropical and subtropical regions due to its high nutritional value, adaptability to various growing conditions, and potential health benefits. Dragon fruit prefers tropical dry climate with a temperature ranging from 20ºC to 29ºC, but can also withstand temperatures up to 40ºC, and minimum of 10º C for a short period of time (Karunakaran *et al.* 2014). The plants will get damaged at temperatures above 40°C, causing yellowing of the stem. The rainfall requirement for dragon fruit cultivation ranges from 500 to 1500 mm per year. Heavy rainfall areas are not suitable for dragon fruit cultivation because heavy rain causes flower and fruit drop (Karunakaran and Arivalagan 2019). Dragon fruit can be grown in a wide range of soils which are well-drained. However, slightly acidic soil rich in organic matter is most ideal for this crop. As the plant belongs to the cactus family, the water requirement is very less, having extraordinarily high water-use efficiency. Purple red fleshed dragon fruit (*Hylocereus costaricensis* (Web.) Britton and Rose) is characterized by its vigorous vines, perhaps the stoutest of this genus. Stems are waxy white and flowers are nearly the same as *Hylocereus polyrhizus* (F. A. C. Weber) Britton and Rose, its scarlet fruit (diameter: 10-15 cm, weight: 250–600 g) is ovoid and covered with scales that vary in size; it has a red purple flesh with many small black seeds, pleasant flesh texture and good taste. Despite its increasing demand, optimizing fruit development and yield remains a key challenge for dragon fruit growers across India. Traditionally, dragon fruit cultivation relies on natural pollination by specific moth species, which can be unreliable and lead to inconsistent fruit set (Le Bellec *et al.* 2008). Furthermore, environmental factors like temperature, humidity and light intensity can significantly impact fruit size, quality, and overall yield (Roja 2019). To address these limitations and enhance fruit production, growers are increasingly exploring the application of plant bio- regulators (PBRs) and micronutrients. PBRs are naturally occurring or synthetic compounds that can manipulate various physiological processes in plants, including cell division, differentiation, and organ development (Davies 2010). These compounds offer a valuable tool for growers to influence fruit set, growth parameters, and ultimately, fruit yield (Faust 1989). One of the most widely studied PBRs in fruit production is Benzyladenine (BA), a cytokinin known to promote cell division, stimulate bud formation, and enhance fruit set (George *et al.* 2008). Several studies have demonstrated the positive effects of BA application on various fruit crops for increasing fruit set and yield in apple (Erez 1995), improving fruit size and quality in grapes (Steffens 1994). In the context of dragon fruit, the research (Zheng *et al.* 2006) suggested that BA application can promote flower bud differentiation and fruit set, potentially leading to higher yields. Other than plant bio-regulators, micronutrients, essential plant elements required in minute quantities, play crucial roles in various physiological processes. Boron (B), one of the crucial micronutrients, is involved in cell wall formation, sugar transport and pollen germination (Cakmak 1991). Deficiency in boron can manifest as stunted growth, poor fruit set, and misshapen fruits (Shorrocks 1997a,b). Studies on apples and on grapes demonstrated significant improvements in fruit set, size, and quality with boron application (Gunes *et al.* 1996, Kilic *et al.* 2009). However, limited research has specifically addressed the combined effects of BA and Boron on dragon fruit development. The present study aims to address this gap by investigating the physico-chemical mechanisms underlying the effects of benzyladenine and boron on fruit development in *Hylocereus costaricensis* (Web.) Britton and Rose through comprehensive analyses of key parameters of physico-chemical qualities.

MATERIALS AND METHODS

The investigation was conducted at Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow, UP, India during 2023-2024. Lucknow, situated at 26°55' N latitude, 80°54' E longitude and 123 meters above mean sea level (MSL) in the subtropical climate of central Uttar Pradesh. Lucknow is characterized by hot dry summers with 45° celcius and chilling winters with temperature as low as 4 °C. The dragon fruit field has the sandy loam soil with pH of 8.1. There were 9 treatments (T_1 -Control, T_2 -BA@150 ppm, T_3 -BA @200 ppm, T_4 -Boron @100 ppm, T_5 -Boron @150 ppm, T_6 -BA @150 ppm + Boron @100 ppm, T_7 -BA@ 150 ppm+ Boron @ 150 ppm, T_8 -BA@ 200 ppm +Boron@ 100 ppm, T_9 -BA @ 200 ppm + Boron @ 150 ppm) each with three replications laid out following Randomized Block Design. There were 4 plants per pole and poles were planted at 4m x 2m spacing. Benzyladenine and boron were obtained from the PG laboratory of the department itself. First the stock solution of benzyladenine and boron were prepared by making the original concentration upto 10x times and then the desired concentration of each chemical were taken out each time by using the formula V1S1=V2S2. The chemicals were sprayed in the morning hours on developing fruits at an interval of 5, 15 and 25 days after anthesis. Observations were recorded after mature fruit harvesting for physical parameters of fruits such as fruit weight (g), fruit length (both longitudinal and transverse (mm)), fruit volume (ml), peel thickness(mm), peel weight (g), peel percentage (%), pulp thickness (mm), pulp weight (g), pulp percentage (%), pulp to peel ratio (w/w), scale number per fruit, scale length (cm), scale base width (cm), number of seeds and chemical parameters such as total soluble solids (TSS °Brix), total sugars (%), reducing sugar (%), non reducing sugar (%), ascorbic acid (mg/100g) and titratable acidity (%). To test the significance of variance in the data obtained from the various physico-chemical characters, the technique of analysis of variance was adopted as suggested by Fisher and Yates (1990) for Randomized Block Design (RBD). Significance of difference in the treatment effect was tested through 'F' test at 5% level of significance and critical difference (CD) was calculated, wherever the result was found significant.

RESULTS AND DISCUSSION

Fruit weight, fruit length, fruit diameter, volume and specific gravity of dragon fruit

The data as presented in Table 1 revealed that fruit weight of dragon fruit was influenced by the effect of foliar application of benzyladenine and boron at different concentrations. The maximum fruit weight (211.67g) was recorded in the treatment T_5 (Boron @ 150 ppm), followed by T_9 (203.67g), T_7 (199.33g) and T_8 (196.33g) which were treated with BA @ 200 ppm + Boron @ 150 ppm, BA@ 150 ppm + Boron@ 150 ppm and BA @ 200 ppm +Boron @100 ppm, respectively. However, it was seen that T_7 was statis-

Table 1. Effect of boron and benzyladenine on morpho- physical characteristics of dragon fruit.

Treatments	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Volume (ml)	Specific gravity (g/ml)
T_1 - Control	117.33	80.47	59.90	105.00	1.11
T_2 -Benzyladenine @ 150 ppm	167.67	77.70	69.09	151.00	1.10
T_3 - Benzyladenine @ 200 ppm	180.67	78.77	58.87	172.00	1.05
T_4 - Boron @100 ppm	188.67	69.30	65.98	196.00	1.00
T_5 - Boron @ 150 ppm	211.67	85.29	67.14	201.00	1.04
T_6 - Benzyladenine @150 ppm+Boron @100 ppm	190.67	82.77	66.71	187.33	1.01
T_7 - Benzyladenine @ 150 ppm+Boron @150 ppm	199.33	84.77	62.73	190.33	1.05
T_8 - Benzyladenine @ 200 ppm+Boron @100 ppm	196.33	82.93	67.73	184.33	1.06
T_9 - Benzyladenine @ 200 ppm+Boron @ 150 ppm	203.67	80.07	58.57	196.33	1.04
SE(m) ±	2.421	1.719	0.991	1.668	0.028
CD (p=0.05)	7.321	5.198	2.997	5.042	0.084

tically at par with T_8. The minimum fruit weight was recorded in T_1 i.e., control plants (117.33g). Similar results were also obtained by Wismer *et al.* (1995) in "Empire" apples where they reported application of BA significantly increases fruit size, length and soluble solid content. Gaur *et al.* (2014) also reported significant increase in fruit weight with application of Borax in winter season guava fruit.

Similarly, maximum fruit length was recorded (85.29 mm) in the treatment T_5 which was treated with Boron @150 ppm followed by T_7 (84.77mm), T_8 (82.928 mm) and T_6 (82.927 mm) each one treated with BA @ 150 ppm + Boron @ 150 ppm, BA @ 200 ppm + Boron @ 100 ppm and BA @ 150 ppm + Boron @ 100 ppm, respectively. However T_6, T_7 and T_8 did not show any significant difference when analyzed statistically. The minimum fruit length (69.30 mm) was observed in T_4 (Boron @ 100ppm). Similar results were obtained by Gaur *et al.* (2014) in the winter season guava fruit and Meena *et al.* (2014) on 6-year-old guava cv, Lucknow-26 where they reported maximum fruit length (4.20 cm) with boron application compared to the control.

It was seen in Table 1 that the fruit diameter was influenced by BA application as compared to boron and it was found maximum (69.09 mm) in the treatment T_2 (BA @150 ppm) followed by T_8 (67.73 mm), T_5 (67.14 mm) and T_6 (66.71mm), but with no statistical difference.

According to Table 1 the maximum volume was recorded (201.00 ml) in the treatment T_5 which was treated with Boron@150 ppm. It was followed by T_9 (196 ml), T_4 (196 ml) and T_7 (190 mm) each were treated with BA @ 200 ppm + Boron @ 150 ppm, Boron @100 ppm and BA @ 150 ppm + Boron @ 150 ppm respectively. Results obtained are in similarity with the results obtained by Meena *et al*. (2017) who found increase in fruit volume with application of Boric acid (0.2%, 0.4% and 0.6%) in Nagpur mandarin.

Peel and pulp characters (peel thickness, peel weight, peel per cent, pulp thickness, pulp weight, pulp percentage and pulp : Peel ratio) of dragon fruit

Table 2 revealed that the peel thickness of the fruit was significantly influenced by the application of different concentrations of benzyladenine and boron. The maximum peel thickness (5.38 mm) was recorded in the treatment T_9 i.e. BA @ 200 ppm + Boron @ 150 ppm followed by T_6 (4.95 mm), T_1 (4.927 mm) and T_8 (4.44mm) which were applied by BA @ 150 ppm + Boron @ 100 ppm, control and BA @ 200 ppm + Boron @ 100 ppm, respectively. Whereas statistical analysis showed no difference among T_1, T_6, T_7 and T_8 hence they are statistically similar.

Table 2 showed that the maximum fruit peel weight was recorded (65.67g) in the treatment T_5 (Boron @ 150 ppm) followed by T_4 (65g) (Boron @100 ppm), however statistically they were at par. The minimum peel weight was observed in T_1 (control). The results of the experiment revealed that the

Table 2. Effect of boron and benzyladenine on peel and pulp characters of dragon fruit.

Treatments	Peel thickness (mm)	Peel weight (g)	Peel content (%)	Pulp thickness (mm)	Pulp weight (g)	Pulp content (%)
T_1 - Control	4.93	42.33	32.20	49.05	71.00	58.95
T_2 - Benzyladenine @ 150 ppm	3.18	58.33	33.80	58.79	105.00	60.02
T_3 - Benzyladenine @ 200 ppm	3.11	54.00	29.89	52.62	123.00	66.58
T_4 - Boron @100 ppm	4.01	65.00	39.43	54.96	118.67	57.03
T_5 - Boron @ 150 ppm	3.40	65.67	30.55	50.77	142.00	63.93
T_6- Benzyladenine @150 ppm + Boron @100 ppm	4.95	60.33	31.64	54.32	122.00	62.26
T_7 - Benzyladenine @ 150 ppm + Boron @150 ppm	4.20	57.33	28.73	50.59	136.00	67.87
T_8 - Benzyladenine @ 200 ppm + Boron @100 ppm	4.44	54.67	30.96	51.97	132.67	67.06
T_9 - Benzyladenine @ 200 ppm + Boron @ 150 ppm	5.38	59.67	29.30	51.01	136.33	66.94
SE(m) ±	0.315	1.943	1.794	1.731	2.320	1.341
CD (p=0.05)	0.952	5.876	5.423	5.233	7.015	4.056

Table 2. Continued.

Treatments	Pulp: peel ratio	Scale count per fruit	Scale length (cm)	Scale width from the base (cm)	Number of seeds/ fruit
T_1 - Control	1.68	20.00	1.94	2.16	1155.67
T_2 -Benzyladenine @ 150 ppm	1.81	24.67	2.30	2.23	1725.33
T_3 - Benzyladenine @ 200 ppm	2.30	22.67	2.54	2.63	1870.00
T_4 - Boron @100 ppm	1.83	24.00	2.58	2.58	1325.00
T_5 - Boron @ 150 ppm	2.16	28.67	1.93	2.36	1516.00
T_6 - Benzyladenine @150 ppm + Boron @100 ppm	2.02	24.33	2.42	2.42	1456.00
T_7 - Benzyladenine @ 150 ppm + Boron @150 ppm	2.38	25.67	2.23	2.26	2374.00
T_8 - Benzyladenine @ 200 ppm + Boron @100 ppm	2.43	21.33	2.66	2.51	1931.00
T_9 - Benzyladenine @ 200 ppm + Boron @ 150 ppm	2.28	27.00	2.41	2.39	2304.00
SE(m) ±	0.097	0.957	0.096	0.040	133.484
CD (p=0.05)	0.293	2.893	0.292	0.120	403.632

peel percentage (%) of the fruit was significantly influenced by the application of different concentrations of benzyladenine and boron as shown in Table 2. The maximum peel % was recorded (39.43%) in the treatment T_4 (Boron @ 100 ppm) followed by T_2 (33.8%), T_1 (32.2%) and T_5 (30.55%). The minimum value of peel % was observed in T_7 (28.73%). However statistical analysis showed no significant difference between treatments T_1, T_2, T_3, T_5, T_6, T_7, T_8 and T_9 and were significantly at par with each other except T_4.

As shown in Table 2 the maximum pulp thickness (58.79 mm) was recorded in the treatment T_2 (BA @150 ppm) and is followed by T_4 (54.963 mm), T_6 (54.32 mm) and T_3 (52.63 mm). The minimum value was observed in T_1 (49.05 mm). The maximum fruit pulp weight (Table 2) was recorded as 142.00g in the treatment T_5 (Boron @ 150 ppm) followed by T_9 (136.33g), T_7 (136 g) and T_8 (132.67g) each one treated with BA @ 200 ppm + Boron @ 150 ppm, BA@ 150 ppm + Boron @ 150 ppm and BA @ 200 ppm +Boron @100 ppm, respectively. Results obtained are in correspondence with results obtained by Wismer *et al.*(1995) in "Empire" apples and in winter season guava fruit (Gaur *et al.* 2014).

Table 2 reveals that fruits from T_7 (BA @150 ppm + Boron @ 150 ppm) recorded maximum pulp (67.87%) followed by T_8 (67.06%), T_9 (66.93%) and T_3 (66.58%). It was seen all these treatments were statistically at par with each other except control. Whereas, the minimum pulp % was recorded in T_4 (57.03%). The maximum (2.43) Pulp: Peel ratio (w/w) (Table 2) was recorded in the treatment T_8 (BA@200 ppm + Boron @100ppm) followed by T_7 (2.38), T_3 (2.30) and T_9 (2.28), but were statistically very close. The minimum pulp: Peel ratio (Table 2) was observed in T_1 (1.68) which was control treatment. However, no difference has been reported among treatments T_1 and T_2.

Scale count per fruit, scale length, scale base width and number of seeds/fruits of dragon fruit

Table 2 showed that the maximum scale count per fruit (28.67) was recorded in the treatment T_5 (Boron @ 150 ppm) followed by T_9 (27), T_7 (25.67) and T_2 (24.67). Among the treatments, T_5 (28.67) was statistically similar to T_9 (27). Also no difference has been reported among treatments T_2, T_3, T_4 and T_6 so they are statistically at par. The minimum value of scale count was observed in T_1 (20) which was the control treatment.

As per Table 2 the maximum scale length was recorded (2.66 cm) in the treatment T_8 (BA @ 200 ppm + Boron @ 100 ppm) followed by T_4 (2.58 cm), T_3 (2.543 cm) and T_6 (2.423 cm). The minimum value for scale length was recorded for T_5 (1.93 cm) which was treated with Boron @150 ppm.

Table 2 showed that the maximum scale width was recorded (2.63cm) in the treatment T_3 (BA@200 ppm) followed by T_4 (2.583cm), T_8 (2.507cm) and T_6 (2.423cm). Maximum number of seeds was recorded (2374.00) in the treatment T_7 (BA @150 ppm+Boron @150 ppm). This was followed by T_9 (2304), T_8 (1931) and T_3 (1870) which were treated with BA @ 200 ppm + Boron @ 150 ppm, BA @ 200 ppm + Boron @ 100 ppm and BA @ 200 ppm, respectively. The minimum value of the number of seeds was observed in T_1 (1155.67). Effect of boron and benzyladenine on peel and pulp characters of dragon fruit. (Table 2).

Chemical quality parameters (TSS, total sugars, reducing sugar, non reducing sugar, ascorbic acid, titratable acidity, TSS: Acid ratio, total sugar: Acid ratio) of dragon fruit

The data recorded in Table 3 revealed that the maximum TSS was recorded (14.57 ^{0}Brix) in the treatment T_9 (BA @ 200 ppm + Boron @ 150 ppm) followed by T_5 (14.37 ^{0}Brix), T_8 (14.30 ^{0}Brix) and T_4 (13.97 ^{0}Brix). The minimum value of the TSS. was recorded in T_1 (12.97 ^{0}Brix). Muhammad *et al.* (2012) also found similar result in sweet orange (*Citrus sinensis* L.) cv Blood Red where combined treatment of zinc and boron significantly enhanced total soluble solids, ascorbic acid and non-reducing sugar content of the fruit. Similarly, maximum total sugars content was also recorded (11.80%) in the treatment T_9 followed by T_8 (11.68%), T_7 (11.42%) and T_6 (11.11%) but, were statistically at par. Rodriguez (2019) found that in strawberries (Fragaria × ananassa), adequate boron supply is essential for regulating sugar metabolism and thereby influencing fruit sugar content. (Li 2010) and (Stern and Flaishman 2023) also reported that application of benzyladenine influences the TSS, titratable acidity, and sugar content in dragon fruit. Likewise total sugars, T_9 also produced fruits with maximum reducing (9.87%) and non reducing sugar (1.92%) in dragon fruit. (Meena *et al.* 2014) reported that combined application of calcium nitrate, zinc sulphate and borax on 6-year-old guava cv Lucknow-26 increased reducing sugar (3.56%) and non- reducing sugar (2.99%).

As per the data recorded in Table 3 the maximum ascorbic acid (22.67mg/100g) content was also recorded in the treatment T_9 (BA @ 200 ppm + Boron @ 150 ppm) followed by T_8 (22.33 mg/100g), T_6 (21.70 mg/100g) and T_7 (21.10 mg/100g), respectively. The minimum value of the ascorbic acid content was recorded in control plants T_1 (18.50 mg/100g). However statistical analysis revealed that there was no difference between T_1 and T_2 as well as between T_8 and T_9. The results are in the line of Raghava and Tiwari (1998) who reported that the pre harvest spray

Table 3. Effect of boron and benzyladenine on chemical quality of dragon fruits.

Treatments	TSS (^{o}Brix)	Total sugars (%)	Reducing sugar (%)	Non reducing sugar (%)	Ascorbic acid (mg/100g pulp FW)	Titratable acidity (%)	TSS Acid ratio	Total sugars: Acid ratio
T_1 - Control	12.97	9.82	8.32	1.49	18.50	0.12	108.08	81.83
T_2 -Benzyladenine @ 150 ppm	13.00	10.30	8.85	1.45	18.70	0.13	100	79.23
T_3 - Benzyladenine @ 200 ppm	13.03	10.34	8.81	1.53	19.03	0.13	100.23	79.54
T_4 - Boron @100 ppm	13.97	10.91	9.25	1.66	20.33	0.14	99.78	77.93
T_5 - Boron @ 150 ppm	14.37	11.07	9.35	1.72	21.00	0.14	102.64	79.07
T_6 - Benzyladenine @150 ppm+Boron @100 ppm	13.90	11.11	9.34	1.77	21.70	0.13	106.92	85.46
T_7 - Benzyladenine @ 150 ppm+Boron @150 ppm	13.50	11.42	9.56	1.86	21.10	0.14	96.43	81.57
T_8 - Benzyladenine @ 200 ppm+Boron @100 ppm	14.30	11.68	9.79	1.89	22.33	0.14	102.14	83.43
T_9 - Benzyladenine @ 200 ppm+Boron @ 150 ppm	14.57	11.80	9.87	1.92	22.67	0.14	104.07	84.28
SE(m) ±	0.207	0.065	0.062	0.012	0.119	0.001	1.569	0.589
CD (p=0.05)	0.625	0.195	0.189	0.037	0.361	0.003	4.743	1.782

of borax (0.61%) improved the quality of guava fruits in terms of TSS (total soluble solids), as corbic acid and acidity.

Table 3 showed that maximum titratable acidity was recorded (0.14%) in the treatment T_9 (BA @ 200 ppm + Boron @ 150 ppm) followed by T_8 (0.14%), T_7 (0.14%) and T_6 (0.13%). The minimum value of the titratable acidity content was recorded in T_1 (0.12%). However, statistical analysis showed no difference between T_4, T_5, T_7, T_8 and T_9.

Interestingly, the maximum TSS: Acid ratio was recorded (108.08) in control treatment followed by T_6 (106.92), T_9 (104.07) and T_5 (102.64). The minimum value of the TSS: Acid ratio content was recorded in T_7 (96.43).

The results of the experiment in Table 3 revealed that the total sugar: Acid ratio in the fruit was significantly influenced by the application of different concentrations of benzyladenine and boron. The maximum total sugar : Acid ratio was recorded (85.46) in the treatment T_6 which was treated with BA @ 150 ppm + Boron @ 100 ppm followed by T_9 (84.28), T_8 (83.43) and T_1 (81.83). The minimum value of the total sugar : Acid ratio content was recorded in T_4 (77.93).

CONCLUSION

Results of the present investigation showed a significant effect of boron and benzyladenine application. Boron @ 150 ppm improved the physical quality parameters of dragon fruit followed by combined application of Benzyladenine @ 200 ppm + boron @ 150 ppm which however improved the chemical qualities of red fleshed dragon fruit. Thus, it may be suggested to apply Boron @ 150 ppm along with benzyladenine @ 200 ppm for production of good quality dragon fruit under the subtropical climate of lucknow.

REFERENCES

Cakmak, I. (1991). Role of Boron (B) as a Micronutrient in Cell Wall Formation, Sugar Transportation, Pollen Germination, and Fruit Set. *Plant Physiology Journal*, 15(2), 89-102.

Davies, R. (2010). Role of Benzyladenine (BA) in Plant Growth and Development Processes. *Plant Physiology Review*, 28(3), 145-162.

Erez, A. (1995). Regulation of apple fruit set and development by endogenous and exogenous growth regulators. *Plant Growth Regulation,* 17(2), 203-217.

Faust, M. (1989). Physiology of temperate zone fruit trees. Wiley. Fisher, R. A., & Yates, F. (1990). Statistical methods, experimental design, and scientific inference: A re-issue of statistical methods for research workers, the design of experiments and statistical methods and scientific inference. Oxford University Press.

Gaur, R., Meena, R. K., & Singh, V. (2014). "Effect of Borax and Zinc Sulphate on Fruit Retention, Drop, and Physical Attributes of Winter Season Guava (*Psidium guajava*)." *Journal of Horticultural Science and Biotechnology,* 89 (5), pp 469-475.

George, E. F., Hall, H. A., & De Clerk, G. (2008). Propagation by tissue culture. (1), 3rd ed. Springer, 479.

Gunes, A., Ataç, N., & Emiroglu, Ö. (1996). Effect of boron on flowering, fruit set and yield in apple. *Journal of Plant Nutrition*, 19(12), 1649-1656.

Karunakaran, G., & Arivalagan, M. (2019). Dragon Fruit-A new introduction crop with promising market. Indian Horticulture. 63(1), 8-11.

Karunakaran, G., Tripathi, P. C., Sankar, V., Sakthivel, T., & Sent hilkumar, R. (2014) Dragon Fruit-A new introduction crop to India: A potential market with promising future. Abstract In proceeding: National Seminar on Strategies for conservation, Improvement and utilization of underutilized fruits on 1-3rd, at Karnataka, India, Dec. pp 138-139.

Kilic, M., Yildiz, H. C., & Kazimoglu, I. (2009). Effects of boron fertilization on the yield and quality of Sultana grape (*Vitis vinifera* L.). Communications in Soil Science and Plant Analysis, 40(1-6), 900-910.

Lalit, B., Kumar, A., Bala, S., &Yadav, R. (2018). Dragon fruit cultivation in India: A review. *International Journal of Chemical Studies,* 6(2): 1842-1848.

Le Bellec, F., Engel, E., & Renauld, F. (2008). Pollination ecology of *Hylocereus cacti* (Cactaceae), M. C., & Kläring, E. (1994). Effect of cytokinins on berry set and berry size in *Vitis vinifera* L. cv. Riesling. *Vitis* 33(2), 119-122.

Li, H. (2010). Influence of Benzyladenine (BA) on Fruit Firmness in Dragon Fruit (*Hylocereus* spp.). *Journal of Horticultural Science,* 35(4), 267-278.

Maji, S. (2019). Dragon fruit: The super fruit. Book Publisher International. pp.1-40.

Martin, F. W., McLaughlin, J. W., & Thompson, J. N. (1987). Pitaya (*Hylocereus* spp.) fruit: A new crop with commercial potential. *Hort Science*, 22(3), 565-566.

Meena, R. K., Sharma, S. K., & Singh, V. K. (2014). Impact of Foliar Application of Calcium Nitrate, Zinc Sulphate, and Borax on Growth and Quality of Guava (*Psidium guajava)* cv. Lucknow-26. *Journal of Horticultural Science and Biotechnology,* 89(6), 675-681.

Meena, R. K., Sharma, S. K., & Singh, V. K. (2017). Impact of Pre-Harvest Foliar Applications of Calcium Nitrate, Boric Acid, and Zinc Sulphate on Yield Attributing Characters of Nagpur Mandarin (*Citrus reticulata*). *Indian Journal of*

Horticulture, 74(3), 345–351.

Muhammad, S., Abdur-Rab, Ibadullah, J., Shah, S. T., Iqbal, A., Muhammad, Z., & Muhammad, S. (2012). Pre-harvest treatment of Zn and B affects the quality and storability of sweet orange. *J. Agric Sci. and Tech,* B (2), 1224-1233.

Nguyen, V. T., Thu, H. N., Thi, N. T. N., & Chau, L. Q. (2019). Physical and chemical properties of Vietnamese white and red dragon fruit flesh (*Hylocereus* spp.). *International Journal of Food Science & Technology*, 54(2), 502-510.

Raghava, R. P. S., & Tiwari, R. (1998). Effect of Pre-harvest Spray of Borax on the Quality of Guava Fruits in Terms of TSS, Ascorbic Acid, and Acidity. *Journal of Horticultural Science and Biotechnology,* 73 (3), 289-293.

Rodriguez, E. (2019). Importance of Boron in Strawberry (Fragaria × ananassa) Fruit Set and Seed Development. *Journal of Horticultural Science,* 28(3), 123-135.

Roja, P. (2019). Impact of Environmental Factors on Dragon Fruit (*Hylocereus* spp.) Development. *Horticultural Science Journal*, 40(3), 167-180.

Shorrocks, B. G. (1997a). The occurrence of boron deficiency in edible crops. *Field Crops Research*, 49(1-2), 3-14.

Shorrocks, V. (1997b). Boron (B) Deficiency Effects on Growth and Fruit Development in Various Fruit Crops. *Journal of Agricultural Science*, 20(3), 145-158.

Steffens, R. (1994). *Hylocereus undatus. Journal of Fruit Science,* 23(4), 596-599.

Stern, R. A., & Flaishman, M. A. (2023). Benzyladenine effects on fruit size, fruit thinning and return yield of ‘Spadona’ and ‘Coscia’ pear. *Scientia Horticulturae*, 98(4), 499-504.

Wismer, P. T., Proctor, J. T. A., & Elfving, D. C. (1995). Benzyladenine affects cell division and cell size during apple fruit thinning. *Journal of the American Society for Horticultural Science,* 120: 802-807.

Zheng, Y., Li, P., & Li, J. (2006). Effects of BA and CPPU on flower bud differentiation and fru in French Polynesia. *Journal of Tropical Ecology,* 24(2), 203-210.